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ON THE

SANITARY VALUE OF FORESTS.

BY

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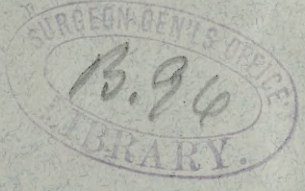

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THE SANITARY VALUE OF FORESTS.

A PAPER READ AT THE CHICAGO MEETING, SEPTEMBER, 1877.

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MAN is the great disturber in the universe. How he has modified history in the world of morals we are told in Holy Writ. How he has

"disturbed
Nature's inmost counsels from their destined aim"

is graven upon the rocks, written upon the sands, and recorded everywhere upon the face of the earth. By neglect or by misuse he has changed a paradise into a desert; by intelligent industry he has reclaimed the sterile waste into an Elysium. Facts which meet us on every hand — in countries the most recently occupied, as well as in those first inhabited by man — furnish many proofs of his ability to waste and destroy as well as to conserve and to improve. Countries formerly teeming with populations which would now starve upon the same areas. "Under the hillocks of sand in the valleys of the Euphrates and the Nile lie temples and palaces, and under the surface of the lifeless desert are buried alike whole cities and the fertile plains which subsisted them."[1]

Denon, the savant, who accompanied Napoleon in his expedition to Egypt, charges the desert to "the decrepitude of the part of the world most anciently inhabited." He says: "May it not have been the abuses of human industry that have reduced it to this state? In this desert there are valleys and petrified wood, consequently there have been rivers and forests; these latter have been destroyed; and from that epoch there has been no more dew, no more mists, no more rain, no more rivers, no more life, no more anything."[2] Speaking of the Desert of Sahara, Champollion, the Egyptologist, thus exclaims: "And so the astounding truth dawns upon us that this desert may once have been a region of groves and fountains, and the abode of happy millions. Is there any crime against nature which draws down a more terrible curse than that of stripping our mother earth of her sylvan covering? The hand of man has produced this desert, and I verily believe every other desert upon the surface of this earth. Earth was Eden once, and our misery is the punishment of our sins against the world

[1] *Eastern Life*, Harriet Martineau.
[2] Denon's *Travels*, London, 1802, vol. i., p. 156.

of plants. The burning sun of the desert is the angel with the flaming sword who stands between us and paradise."

A writer in a recent number of the "Popular Science Monthly" is equally specific, and, if possible, more emphatic. He says: "The physical history of our planet records the steady growth of a desert, which made its first appearance on the dry table-land of Southern Syria, and, gradually spreading eastward down the valley of the Euphrates toward Afghanistan, and westward along both sides of the Mediterranean, now extends from Eastern Persia to the western extremity of Portugal, and sends its harbingers into Southern France and the southeastern provinces of European Russia. Like a virulent cancer, the azoic sand-drifts of the Moab desert have eaten their way into Southern Europe and Northern Africa, and dried up the life-springs of districts which, beyond all dispute, were once the garden regions of the earth." [1]

More soberly stated, but scarcely less explicit, is the declaration of Dr. Hough, Chairman of the U. S. Commission on Forests: "We cannot account," he writes, "for the changes which have occurred since those sunburnt and sterile plains, where the traces of man's first civilization are found, were clothed with a luxuriant vegetation, except by ascribing them to the improvident acts of man in destroying the trees and plants which once clothed the surface and sheltered it from the sun and winds. As this shelter was removed the desert approached, gaining new power as its area increased, until it crept over vast regions once populous and fertile, and left only the ruins of former magnificence." [2]

The substantial accuracy of these enunciations is abundantly proven in the comparison of their former state with the present condition of the regions of the earth the longest inhabited by man. Contemporary history abounds in examples of a similar want of provident forethought in our own time; and it cannot be doubted that there is a wide-spread belief that there is danger of a repetition in the western world of the folly which has so disastrously changed so many portions of the eastern hemisphere. It is well, then, that our National Legislature has created a Commission to investigate the subject of our Forestry, and it would be well that this Association should give such emphasis to efforts made in the direction of judicious forest conservation and tree-planting as a calm and careful investigation will show to be demanded by the varied needs of our race.

But is the fear here alluded to well-founded? Will nations continue to rise, each higher than its predecessor, only that their fall may be the more appalling, and their destruction the more complete? Will some future antiquary dig among the sands of the desert of the Mississippi, or of the Ohio, for the evidences of the dead and buried civilization of the nineteenth century? In a word, is there danger that "this fair and goodly earth" of ours is to be added in the not very distant future to the list of worn-out worlds astronomers tell us of? Or, is there not, rather, in an enlightened Christian civilization, a well-grounded hope that a knowledge of the errors of the past will serve to indicate the remedy for the future?

[1] *Op. cit.* Aug. 1877.

[2] *Trans. Am. Assoc'n Adv. Science*, 1873.

There is an inevitable antagonism — an irrepressible conflict — between the wants of man and the existence of the forest. The necessities of populations have, in all time, required the destruction of forests, and the same necessities will continue to demand that the fertile plains be devoted to cultivation and the hills to pasturage, that men may thus be fed and clothed. In ancient times defective methods of culture, ignorance of physical laws, especially those which relate to the rotation of crops and the renewal of soils, gave over to the desert, by slow but certain process of deterioration, the fertile plains which are regarded by Jew and Gentile alike as the cradle of the race. Many times in recorded history have the pressure of increasing wants and diminished fertility demanded the clearing of new areas of forest for tillage, pasturage, or habitation; but for the possibilities opened up in modern times by improved implements for cultivation of the soil, by an enlightened experience and scientific research, which have shown how fertility may be perpetuated and even the desert may be reclaimed, the question of the continued habitability of our globe would, by this time, have become an unpleasant one.

It is asserted that forests influence public health by their effects upon the atmospheric constituents, water supply, climate, and malaria. These points will be briefly commented upon in the order in which they occur, as far as possible ; but, from their intimate connection, they cannot be entirely separated in the discussion.

A reference to some of the familiar facts in animal and vegetable physiology is necessary to a correct understanding of the relations the great divisions of organic life sustain to each other. That they are complementary, each of the other, is shown in the fact that animals exhale carbonic acid which growing plants decompose, storing the carbon in their tissues, where it becomes fixed, and returning the oxygen to the air. By means of respiration, which is an exclusively animal function, oxygen is taken into the body, where, uniting with atoms worn out in the various physical and mental processes it promotes their removal, thus making room for new tissue-substance, fitted for new uses, vivified by the wonderful chemistry of the vegetable world. This molecular metamorphosis, this "renewal of life," is a necessity to animal existence, which ceases only at death. Every living animal is thus constantly exhaling into the atmosphere carbonic acid, which, if in sufficient excess, would put out the life of all animated beings as water puts out flame. The necessity of an abundant and active vegetation for the depuration of the atmosphere from the excess of carbonic acid thus set free becomes apparent when, in connection with this source, we take into account the immense quantities added to the atmosphere by the decomposition of vegetable matter, by the decay of all dead organisms, by the combustion of the various forms of carbon, as wood, peat, oils, coal, etc., for the production of heat and light. What has been done in past eons, in this respect, to fit the earth for human habitation, may be very imperfectly conceived by estimating the amount of carbon stored in the soil as humus, and in the coal fields, — those vast storehouses of the flora of the prehistoric world. So far as known there is no source of free oxygen except the vege-

table kingdom. "All flesh is grass." Animals can produce none of the elements necessary for their sustenance, but subsist upon vegetable products elaborated by vegetal forces from inorganic nature. "Hence," according to Professor Gray, "the perfect adaptation of living beings to each other; each removing from the atmosphere what would be noxious to the other; each yielding to the atmosphere what is essential to the continued existence of the other."[1]

The necessity of a preponderance of vegetable over animal life to the health of the latter is beautifully demonstrated in the aquarium. It is there shown that subaqueous vegetation fulfills the same office in preserving the purity of the air in water that land plants do in the atmosphere. It has been found that there can hardly be too large a proportion of plants, as long as they do not decompose, for the health of the animals; but the preponderance of animals over plants invariably disturbs the balance and leads to the destruction of the animals.

The necessity, then, of covering the general face of the earth with vegetation, that animals may not be suffocated with atmosphere surcharged with *carbonic acid*, may be fairly assumed; and one special office of trees in this regard may be the more permanent withdrawal of carbon, retaining it for centuries even, and then returning it to the earth as humus, instead of restoring it to the atmosphere as carbonic acid.

Isolated experiments have been made from time to time, since Schoenbein announced his discovery of *ozone*, upon its influence upon human health, and the laws by which it is governed, but so far as I know it has no practical use in this inquiry.[2]

2. There are few questions in public hygiene more important than that which relates to the *water supply*. The special need here is: That the water be pure, and that the supply be abundant, constant, and universally distributed.

That forests influence the water supply by condensation of aqueous vapor from the atmosphere and promoting its precipitation in rain and dew, and by storing up the excess of rain-fall, and regulating the supply of streams and springs, may be proved, I think, by a "cloud of witnesses," a few of whom only can be introduced here.

[1] Gray's *Structural and Systematic Botany*, 1876, p. 201.

[2] Recent observations on the allotropic form of oxygen would seem to give a more important place to ozone in its relations to human health than is here indicated. By virtue of its extraordinary affinity for the products of decomposition it undoubtedly purifies the air of localities in which it abounds by destroying noxious gases and by oxidizing decomposing organic substances. It also promotes nutrition and healthy blood-changes by supplying to the respiratory organs a more active form of oxygen than is found in the normal constitution of the atmosphere. The turpentine exhaled from pine and hemlock forests possesses to a greater degree than any other known substances the power of converting the oxygen of the atmosphere into ozone. Next to this are, probably, those essential oils which are most effective as germicides and antiseptics, — *e. g.*, the oils of mustard, bitter almonds, and eucalyptus. Hence, probably, the often undoubted efficacy of residence in high, dry, piney regions in preventing or arresting phthisical development; and hence, too, the supreme importance of preserving such evergreen forests as experience has shown to be especially useful in this regard. — [G. L. A., July, 1879.]

White, of Selborne, in one of his charming letters, thus relates how the trees condensed the moisture in England one hundred years ago: "In heavy fogs, on elevated situations especially, trees are perfect alembics, and no one who has not attended to such matters can imagine how much water one tree will distill in a night's time by condensing the vapor, which trickles down the twigs and branches so as to make the ground below quite in a float. In Newton Lane, in October, 1775, on a misty day, a particular oak in leaf dropped so fast that the cartway stood in puddles and the ruts ran with water, though the ground in general was dusty." [1]

Fantrat, in the forests of Hallette last year, first measured the quantity of rain both above and below the foliage of trees, and endeavored to take account of the evaporation. He found that the soil covered with forests received six tenths of the whole rainfall, the trees having intercepted four tenths. The hygrometric observations showed that there was always in the neighborhood of the forests a greater quantity of vapor than in the neighborhood of large areas of cleared lands. He concluded that "this envelope of moisture is beneficial to the neighboring cultivated lands, as it flows out upon them during the night time, when such lands are cooled by nocturnal radiation, and the radiation is precipitated upon them as dew." [2]

The most recent observations at this point are thus reported by the same observer, in the "Bulletin of the Paris Academy of Sciences," session of August 6, 1877: "If vapors dissolved in the air were apparent like fogs, we should find forests enveloped by a large moist screen, and for pine forests the envelope would be greater than for others. The forest, too, receives more rain than the neighboring land, and the fact is more pronounced in the case of pine forests than in others. Pines retain in their branches more than half the water poured on them, while leafy trees let 58 per cent. go to the ground."

I am indebted to our colleague, Dr. Lyman, for a kindred observation of his own among the mountains of Hawaii. He says: "The forest belt extends from 1,500 or 2,000 feet above the level of the sea to an elevation of 7,000 or 8,000 feet. Above and below these levels the mountains are unwooded. It is a very common thing to see a dense bank of clouds apparently clinging to the forest and breaking off abruptly into clear air above and below the line of trees."

Two points of observation have been established in Prussia, — one over a young forest of *Pinus sylvestris*, some 40 feet high, and the other over a bare sandy plain 300 meters distant from the edge of the wood, and at the same height from the ground. Twelve months' observations showed that, of the total rain-fall within that period, ten per cent. more fell over the trees than over the bare sand 300 meters distant. Experiments of a similar nature over woods of oak and beech gave an excess of five per cent. only in favor of the wooded site. Further, the mean state of the saturation of the air over the wood was ten per cent. higher than of that over the bare expanse of sand; the former holding much more water in suspension than the

[1] *Natural History of Selborne*, Letter 7.

[2] *Annual Record of Science and Industry*, 1876, p. 78.

latter. The ground under the trees retained far more water in suspension than the exposed earth, — the evaporation being only one sixth of that outside their friendly shelter.[1]

' The Special Commission of the Royal Academy of Vienna found that there had been a very decided lowering of the mean and low water heights of the rivers Rhine, Elbe, and Danube during the last hundred years; that the diminution of the amount of water in those rivers indicated a decrease in the productive power of the springs, further proof of this being found in the lessening of the water in the brooks, aqueducts, and fountains, and gave the following as the probable cause: "1st. The uprooting of the forests as affecting the yearly amount of precipitation. 2d. The increased evaporation from the surface of the earth thus denuded. 3d. In this change of the surface condition of the earth, the amount of water precipitated, instead of being held in reserve and slowly percolating, rushes suddenly into the streams, and for a short time high water prevails, which is followed by a long period of dryness. The copiousness of the springs and the fullness of the rivers do not entirely represent the amount of the yearly precipitation of water. On the one hand, a portion is given back to the atmosphere by evaporation; and on the other, a portion, determined in amount by the physical conditions of the ground, penetrates into the soil and affords nourishment for the springs. The influence of the woods in both these tendencies cannot be overestimated."[2]

That geographical mystery of the ages, the source of the Nile, is not yet fully solved, but the amazing copiousness of its flood, and the steadiness of the supply, seem fully explained when we read descriptions by recent African explorers of the equatorial forests which give it birth, and from which it draws its supplies. "Into these forests," says Dr. Livingston, "the sun, though vertical, cannot penetrate, except by sending down at midday thin pencils of light into the gloom. The rain-water stands for months in the stagnant pools." Add to this the earthy sponges which exist nowhere else, and the "pitiless rain," of which he had occasion to write so often in his last journal, six inches falling in a single night, and the requirements are all supplied.

Dr. Charles Beke writes from Cairo that there were two and a half millions of trees in cultivation in Egypt in 1860, and that the number had been doubled in 1874. He found trees along the road, and so extensively planted as to give the appearance of a well-wooded country. "Already," he says, "there seems to be a change of climate as a consequence of increased tillage and forest culture: Egypt is in fact losing its proverbially rainless character. Rain has begun to be felt as an annoyance at Alexandria, and is remarkably increasing at Cairo."[3] By still more recent travelers we are informed that the arable area has been increased hundreds of square miles, and the rain-fall has been more than doubled over the greater portion of inhabited Egypt within the life of the present generation. By means of

[1] Biedermann's *Centralblatt.*
[2] *Smithsonian Report,* 1875.
[3] *Smithsonian Report,* 1875.

artesian wells, and planted groves of palms around them, stations have been created in the Sahara for caravans, and there is good reason for the faith that the multiplication and extension of these oases may result in the restoration of its ancient fertility and habitability to Northern Africa.

Of a like nature is the experience of many portions of the American Desert: the testimony of army officers being both frequent and emphatic as to the effects of areas of cultivation and tree-planting in modifying the rain-fall and other climatic conditions. Dr. Letterman, for example, thus reports the experience at Fort Union in New Mexico: "The climate of the country seems to be changing, especially in regard to the increase of rain; and, from the universality of the opinion among those who have resided longest in the Territory, little doubt can be entertained of its correctness. It is probable that this increase may, in a measure, be owing to the greater extent of land brought under cultivation."[1]

How these, as well as many other desert regions, may be reclaimed, is thus described in the report of Clarence King: "Notwithstanding the apparent want of moisture in the soil, it must be the reservoir from which vegetation draws its entire supply. The loose character of the deposits which fill the valleys and form the foot-hills, not only allows a ready passage for the roots to any necessary depth, but, especially through the force of capillary attraction, compels the retention and absorption from beneath of a sufficient amount of water for the temporary extraordinary needs of these perennial species. And this natural resource of the vegetation must be taken into account as greatly favoring the possibility of the successful introduction of orchard, vineyard, or other tree culture in these at present desert territories."[2]

The Smithsonian Institution has issued[3] the "Results of Meteorological Observations made at Marietta, Ohio, between 1826 and 1859 inclusive, by S. P. Hildreth, M. D., together with the results of Observation at the same Place by Mr. Joseph Wood, between 1817 and 1823," being an almost continuous record of temperature and rain-fall for forty-two years. Dr. Hildreth continued his observations until his death in 1863, since which time they have been continued by his son, Dr. George O. Hildreth, to the present date, sixty years in all. Marietta was the first settlement in Ohio, which was celebrated even among the Western States for the grandeur of the forests which covered almost its entire surface. According to the Report of the Statistician of the Department of Agriculture for 1875, the area of forests in that portion of the State is now about thirty-three per cent.; but such forests as remain are greatly influenced in their character as to density by the thinning of the trees and the absence of undergrowth. A letter with which I have been recently favored by Dr. G. O. Hildreth gives in brief all that is necessary in the present inquiry. He writes: "I am unable to perceive any decided diminution of the fall of rain corresponding to the settlement of the country and the removal of forests. The small streams

[1] *Medical Statistics U. S. Army*, vol. ii., p. 221.
[2] *Geological Exploration, 40th Parallel.*
[3] *Smithsonian Contributions to Knowledge*, No. 120.

dry out in the summer more thoroughly, and rise and fall more rapidly from rains at all seasons of the year; but I do not perceive any change in the amount of rain, other than that alternation or variation, from year to year, which seems to occur without law or assignable cause. One effect upon the large streams of water from the removal of trees from their banks has been the washing of the banks, the widening of the streams, and a lessening of the depth of water in the channels, especially in the summer."

I may be pardoned if I here introduce my personal testimony as to the experience of the opposite side of the State of Ohio, embraced in the lower portion of the Miami Valley. The first twenty-three years of my life I was a resident of Hamilton. During that time business, opportunity, and inclination gave me a somewhat intimate acquaintance with the physical peculiarities of the region between Dayton and Cincinnati, including an area of some four hundred square miles. At the date of my earliest recollection, the areas of heavy forest were quite large over a considerable portion of this region, and that of cleared lands small in comparison. A recent visit, after an absence of thirty years, showed some remarkable changes. The greater portion of the forest had disappeared; the occasional clumps of trees that remained were cleared of their undergrowth, partaking much more of the character of the open grove than of the forest of old. Although the season was early spring, the river and creeks were almost at low-water mark; many of the springs, which were formerly perennial, were now dry; and farms which had formerly been by nature well-watered now depend solely during the summer months upon wells and cisterns. As to the effect of this denudation upon the rain-fall in the Miami Valley, I cannot speak from a record, but am able, through the kindness of Dr. C. Falconer, of Hamilton, to give the general impressions of one who has been during the years embraced in these changes an interested, careful, and competent observer. He writes: "I doubt if these causes have affected the hygrometry of our county perceptibly. We have just cut about the best crop of small grain our county has ever produced. Of one steady change depending upon our surface moisture, I have been a practical observer for forty-five years, which has resulted in the constant diminution of malarious diseases. The clearing out of the small streams by the farmers, and the underdraining of their lands to increase their crops, has greatly lessened the importance of malaria as a factor in our diseases and practice — excluding it entirely in many districts."

5. "Climate, in its modern acceptation, signifies that peculiar state of the atmosphere in regard to heat and moisture which prevails in any given place, together with its meteorological conditions generally in so far as they exert an influence on animal or vegetable life." [1] The fundamental condition and controlling cause of all climatic phenomena is the heat received from the sun. This produces its varied effects by direct terrestrial radiation, and by means of its secondary effects upon vital forces, aeriform fluids, and all mobile forms of matter. Heat increases the capacity of air for water. Thus at 14° Fahrenheit one cubic foot of air is saturated with one grain of water;

[1] *Encyclopedia Britannica*, ninth edition, Art. "Climate."

at 30° with two grains; at 56° with five grains; at 80° with eleven grains; and at 88°, a temperature not uncommon in this latitude, the point of saturation is not reached until fourteen grains of water has been added to each cubic foot of air.[1] The effect produced upon climate, then, by an abundant supply of water to a heated atmosphere becomes quite apparent. The special office of trees in this regard, besides their influence upon terrestrial radiation, which has already been alluded to, is to draw up their needed moisture from lower strata than those accessible to smaller plants. Under ordinary circumstances plants do not absorb either water or vapor from the atmosphere, and it is probable that the entire supply of water is drawn through the roots from the earth. Having performed its office in leaf digestion, the superfluous moisture is evaporated from the leaves. The amount of aqueous vapor thus delivered to the atmosphere by a full-grown tree in full leaf and active growth is enormous. Von Pettenkoffer by careful experiment found the amount of evaporation to be eight and a half times more than the amount of rain-fall upon the same area.[2] This excess must sometimes be pumped up from great depths, and one important office of trees in preventing the excessive dryness of the atmosphere is, even in seasons of extraordinary drought, to maintain that moisture in the atmosphere so necessary to the welfare both of plants and animals. It has been found practically impossible for grasses, cereals, and the smaller forms of vegetation to meet the demands, in this regard, of the occasional seasons of excessive drought which are liable to visit almost any region deprived of its forests. Hence we have in the India of our day frequent droughts, fever, and famine, alternating with swollen streams and their consequent frightful devastations, chiefly caused by the wanton destruction of its trees.

4. Malaria, as a factor in human disease, has been alluded to and will receive short mention here. That malaria is organic seems to be generally regarded as probable and almost proved. The two essential agencies in the production and decomposition of all organic forms, whether animal or vegetable, are heat and moisture. The combined influence of these is undoubtedly essential to the production and dissemination of malaria. Whether, when all the attainable facts are gathered together and summed up, it shall be found to be a microscopic fungus as believed by Professor Salisbury, or equally minute algæ as now appears to be almost demonstrated by Signor Lanzi of Rome,[3] it is quite certain that many of the conditions of its growth and diffusion are under human control: 1st. It is found most constantly and in greatest concentration in moist localities. The remedy here is thorough drainage and tillage. This seems to be efficacious everywhere. The swamp of Orx, on the Gulf of Gascony, was surrounded with forests of pine, notwithstanding which the adjacent communities suffered severely from fever until the swamp was thoroughly drained, when the insalubrity disappeared. In the valley of the Rhone fevers have perceptibly diminished since considerable clearings have permitted the free access of the

[1] Flammarion, *Atmosphere.*

[2] *Nature*, December 19, 1872, p. 118.

[3] *Medical Times and Gazette*, December 2, 1876.

sun. The jungle fever of India and the coast fever of Africa, the country fever of our Southern States and the ague of the West, have all yielded to the magic influences of sunlight and drainage. 2d. Malaria seems to be arrested in its transmission from the site of its genesis by forests and tree belts, and perhaps in an equal degree by skirts of rapidly-growing annuals. The eucalyptus among trees, and the sunflower among annuals, thus far stand at the head of their respective classes as filters or destroyers of malaria. Nor is this a new thing under the sun. The Romans recognized at an early day the value of rows of trees and masses of forest as a barrier against the diffusion of febriferous poison, and that such defences might never be disturbed, they were placed under the protection of their gods. So many facts have been recorded, and so many more exist in the unrecorded experience of medical observers residing in malarial regions, that this effect may be assumed as proved. Professor Flint says: "Malaria has an attraction for trees and other organic materials. It is found to be perfectly practicable to prevent the access of malaria to dwellings by planting large trees or thick shrubbery in the immediate vicinity between the originating points and the house to be protected." Professor Metcalfe is of the same opinion.[1] "Malaria," he says, "has an affinity for dense foliage, which has the power of accumulating it when lying in the course of winds blowing from malarious localities." Professor Tyndall made an eloquent and quite effective plea for the use of the imagination in scientific inquiry, and in the various discussions as to the essence of malaria much warranted liberty has been taken in this direction. In view of the established facts resulting from the investigation of Darwin and others into the habits of the insectivorous plants, we have reason to expect new light from that source upon the ætiology and prevention of diseases of malarious origin or complication, and of those caused by organic emanations from living plants and animals. Though in the present state of our knowledge I do not hazard the opinion, I may be excused for expressing the hope that the near "future hides in it" a *positive* science of preventive medicine far in advance of our present most sanguine expectations.

The sanitary value of forests, according to our present light, may be thus summed up: —

I. Forests increase the amount of condensation over their own areas, but by reason of the amount intercepted by their leaves and stems the annual rain-fall at the earth's surface is not, perhaps, materially affected by their presence or absence in regions well covered with other vegetation and thoroughly cultivated.

II. By means of their interlaced roots, mosses, lichens, and humus they check the efflux of superfluous rain-fall, thus regulating the water supply in streams and springs, and decreasing the proportion of the annual precipitation that is borne to the sea by the natural drainage of the country.

III. Forests diminish the evaporation from the earth's surface,[2] but this

[1] *Monograph on Malaria*, U. S. Sanitary Commission, 1862.

[2] "The evaporation from a surface of water in the woods was 64 per cent. less than outside the same." Ebermayer, in *Journal of Meteorology*, vol. viii., p. 253.

hygrometric deficiency is much more than compensated by the increased evaporation from their leaves. Forests may thus become beneficial, or otherwise, according to circumstances. The change which tree-planting has already produced upon our western plains is thus far an unmixed good, but, by increasing the humidity of the climate of certain health resorts, valued mainly for their dryness, — as Denver, for example, — extensive tree-planting is not unaccompanied with evil.

IV. Trees modify temperature, — wooded countries being warmer in winter and cooler in summer. This they do by radiation, but, owing to their slow conducting power, the times of their daily maximum and minimum do not occur until some hours after the same phases in the temperature of the air, thus distributing the heat of the day more equally over the twenty-four hours. The special significance of this effect lies in the fact that, as relating to human health, the daily range of the thermometer is of more importance than the mean temperature of whole seasons.[1]

V. Trees radiate and evaporate through a stratum of air equaling in thickness their height, whilst the radiation and evaporation from grasses, plants, and shrubs is confined to a stratum limited to the comparatively lesser planes which they occupy.

VI. From the preceding it may be fairly inferred that they modify climate to the extent of influencing the amount and character of the diseases in their vicinity. In this inquiry residence *in* forests is not considered, universal experience having shown those situations which are permanently shaded to be insalubrious.

VII. Forests and tree belts are of undoubted value in preventing the dissemination of malaria.

VIII. Trees are of positive sanitary value in affording shelter from the excessive heat of the sun, from the violence of winds, and in promoting æsthetic culture.

IX. The importance of devoting to forests all regions unfit for profitable culture, and of protecting them by an enlightened public sentiment, as well as by legal enactment, may be fairly assumed as a sanitary as well as an economical necessity.

X. And finally, — as specially relating to the city whose hospitality we are now enjoying, — the importance of abundant and extensive tree-planting, especially on its western and southwestern exposures, which was so ably urged by our worthy President in 1869, is such as should command the immediate and earnest attention of every one interested in its welfare.

[1] The yearly oscillations of temperature in the woods are 7° (Cent.) less than in the open fields. The yearly maximum of temperature is found to be 5° (Cent.) lower. Likewise the daily oscillations of temperature in summer amount to 6° (Cent.) less than that of the open fields. The temperature of the soil in forest-land was, in summer, 4° (Cent.) less than that of the unwooded soil. Ebermayer's "Physical Influence of the Woods," *Jour. of Met.*, vol. viii., pp. 209, 232.